

# MULTIPLE LAYERS LAMINATED POLYOLEFIN FOAM

## BACKGROUND OF THE INVENTION

### 5 1. Field of the Invention

10 The present invention relates to a sheet or board like multiple layers laminated polyolefin foam suitable as partitions for containers, sheets or core materials for construction industry and civil engineering or for industrial goods, goods-delivery boxes in packaging applications, materials for harvest boxes and the like. More specifically, the present invention relates to a multiple layers laminated polyolefin foam in which multiple  
15 polyolefin layers are laminated on at least one side of a polyolefin foam sheet by a coextrusion method.

### 2. Description of the Related Art

20 Sheet or board like polyolefin foams have been widely used for various containers such as food trays, lunch boxes, bowls, cups, goods-delivery boxes, harvest boxes, and the like.

25 However, the polyolefin foams that have been used for the above-described applications had an expansion ratio of less than 3 times, were heavy, and had poor processability. Recently, the polyolefin foams have been suggested in which

a polyolefin sheet was laminated on a polyolefin foam with an expansion ratio of 3 to 20 times. Such foams were disclosed, for example, in Japanese Patent Applications Laid-open Nos. H10-748, H11-105132, and H11-277696.

5 Japanese Patent Application Laid-open No. H10-748 disclosed a board-like foam in which a synthetic resin film with a tensile strength of no less than  $10 \text{ kg/mm}^2$  was laminated by a thermal lamination method on a board-like polyolefin foam with a density of  $0.07$  to  $0.25 \text{ g/cm}^3$ . Furthermore, Japanese  
10 Patent Application Laid-open No. H11-105132 disclosed a multiple layers synthetic resin foam in which a resin layer containing an inorganic filler in an amount of no less than 10 wt.% was laminated on a polyolefin foam sheet with a density of  $0.5$  to  $0.1 \text{ g/cm}^3$  by a coextrusion method.

15 Japanese Patent Application Laid-open No. H11-277696 disclosed a method for the manufacture of a foam in which a polyolefin is laminated on at least one side of a propylene foam by a coextrusion method, wherein a foam having a surface layer extruded to have a tubular shape is cut open  
20 to obtain a sheet-like foam and taken up under heating to a temperature no less than  $20^\circ\text{C}$  below the thermal deformation temperature of the polyolefin constituting the surface layer; the application also disclosed a laminated foam sheet or board. However, those products did not always have  
25 satisfactory properties. Thus, bending strength was insufficient as compared with that of the foam with an expansion ratio of less than 3 times, sufficient rigidity

could not be obtained, and adhesion between the foam and laminated resin was locally insufficient, causing local peeling.

Furthermore, in applications such various containers  
5 such as goods-delivery boxes or partitions for containers, and the like, it is required to provide a polyolefin foam with functional properties by laminating it with a resin layer having an antistatic agent, an electrically conductive additive, a fungicide or a colorant added  
10 thereto.

In order to provide a laminated foam with functional properties such as antistatic properties, an additive providing the functional properties such as antistatic properties is mixed with a polyolefin used for lamination.  
15 In such case, however, a laminated foam with sufficient rigidity often cannot be obtained. Accordingly, the present invention provides a multiple layers laminated polyolefin foam combining small weight with sufficient rigidity.

Furthermore, the present invention also provides a  
20 multiple layers laminated polyolefin foam in which multiple polyolefin layers are laminated on at least one side of a polyolefin foam by a coextrusion method, this multiple layers laminated polyolefin foam combining small weight with sufficient rigidity. Moreover, the present invention  
25 provides a multiple layers laminated polyolefin foam having excellent antistatic properties and combining small weight with sufficient rigidity.

The inventors have conducted an intensive study of the melt flow rate, etc. of polyolefins laminated on polyolefin foam by a coextrusion method and have discovered that the closed cell ratio of the foam is decreased and sufficient rigidity cannot be obtained when the melt flow rate of the polyolefin laminated by a coextrusion method is low, the thickness of the polyolefin is large, and the density of the laminated foam is small. However, this information led to a new problem. Thus, the melt flow rate of a polyolefin is unavoidably decreased by the addition of an additive providing the laminated polyolefin with functional properties with an object of providing the laminated foam with functional properties such as antistatic properties and the like, and even when a multiple layers laminated polyolefin foam combining small weight with high rigidity is attempted to be obtained by laminating a polyolefin with a large thickness by a coextrusion method, the closed cell ratio of the foam decreases and a sufficient rigidity cannot be obtained. To resolve this problem, the inventors have conducted additional intensive study which led to the conception of the present invention.

#### SUMMARY OF THE INVENTION

(1) The present invention relates to a multiple layers laminated polyolefin foam in which multiple polyolefin layers are laminated on at least one side of a polyolefin

foam by a coextrusion method, wherein the thickness of the outermost layer constituting the multiple polyolefin layers is 5~80  $\mu\text{m}$ , and the density  $d$  (g/L) of the polyolefin foam, the melt flow rate  $X$  (g/10 min) of the polyolefin

5 constituting the innermost layer among the multiple polyolefin layers, and the thickness  $Y$  ( $\mu\text{m}$ ) of the innermost layer of the multiple polyolefin layers satisfy the following relationships (1) to (4):

10  $Y \leq 0.29dX$  ... (1)

$5 \leq X \leq 40$  ... (2)

$70 \leq Y \leq 300$  ... (3)

$100 \leq d \leq 300$  ... (4)

15 (2) The base resin constituting the polyolefin foam and polyolefin layers in the multiple layers laminated polyolefin foam in accordance with present invention is of at least one type selected from polypropylenes and polyethylenes. (3) Further, the outermost layer among the  
20 polyolefin layers in the multiple layers laminated polyolefin foam in accordance with present invention contains a polymer-type antistatic agent so that the surface resistivity is no more than  $1 \times 10^{13} \Omega$ . (4) The  
25 polymer-type antistatic agent comprises at least one of polyetheresteramides and polyethers as the main component. (5) The outermost layer among the polyolefin layers in the multiple layers laminated polyolefin foam in accordance

with present invention contains 2~30 wt.% polymer-type antistatic agent. (6) The thickness of the entire laminated foam in the multiple layers laminated polyolefin foam in accordance with present invention is 2~10 mm and the closed  
5 cell ratio of the laminated foam is no less than at least 60%.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 In the multiple layers laminated polyolefin foam (simply referred to as "laminated foam" hereinbelow) in accordance with present invention polyolefin layers are laminated on one side or both sides of a polyolefin foam sheet or board (simply referred to as "foam" hereinbelow).  
15 The laminated foam has multiple polyolefin layers composed of at least two layers, that is, an innermost polyolefin layer (referred to as "innermost resin layer" hereinbelow) which is laminated on the foam surface and bonded thereto and an outermost polyolefin layer (referred to as  
20 "outermost resin layer" hereinbelow) located on the surface of the laminated foam and, if necessary, comprises resin layer(s) disposed between the innermost resin layer and outermost resin layer.

Furthermore, in the laminated foam in accordance with  
25 present invention, the thickness of the outermost layer is 5 to 80  $\mu\text{m}$ , and the density,  $d$  (g/L), of the foam, the melt flow rate,  $X$  (g/10 min) of the polyolefin constituting the

innermost resin layer, and the thickness,  $Y$  ( $\mu\text{m}$ ), of the innermost resin layer satisfy the following relationships (1) ~ (4):

5  $Y \leq 0.29dX$  ... (1)

$5 \leq X \leq 40$  ... (2)

$70 \leq Y \leq 300$  ... (3)

$100 \leq d \leq 300$  ... (4)

10 When  $d$ ,  $X$ , and  $Y$  do not satisfy the above relationships (1) ~ (4), a laminated foam with excellent physical properties such as rigidity and compressive strength cannot be obtained. Furthermore, when  $Y$  exceeds the value calculated as  $0.29 (\mu\text{m} \cdot \text{L} \cdot 10 \text{ min} \cdot \text{g}^{-2}) \cdot d \cdot X$ , under the  
15 conditions allowing the innermost resin layer with a thickness  $Y$  and a melt flow rate (abbreviated as MFR hereinbelow)  $X$  to be laminated on a foam with a density  $d$  and bonded thereto, the closed cell ratio of the surface portion of the foam onto which the innermost resin layer is  
20 laminated will decrease, degrading physical properties of the foam. As a result, physical properties of the obtained laminated foam will also be greatly degraded. Furthermore, the decrease in the closed cell ratio of the foam can also cause local peeling of the innermost resin layer. The  
25 above-mentioned decrease in the closed cell ratio of the foam is apparently caused by the collapse of the cell structure of the foam sheet under the effect of heat

because the softened or melted synthetic resin layer (innermost resin layer) that can be laminated on the foam has a very high heat capacity. Further, Y is preferably no more than  $0.26dX$ , even more preferably, no more than  $0.23dX$ .

5        When X is less than 5 g/10 min, if the resin constituting the innermost resin layer is heated to a temperature at which the innermost resin layer demonstrates good lamination and bonding ability in lamination on the foam, then the heat capacity of the resin increases and  
10        this heat can decrease the closed cell ratio of the foam. On the other hand, when X exceeds 40 g/10 min, the appearance such as surface smoothness can be unsatisfactory. The MFR:X, of the resin constituting the innermost resin layer is preferably 8 to 40 (g/10 min), even more  
15        preferably, 10 to 40 (g/10 min).

      When Y is less than 70  $\mu\text{m}$ , physical properties such as rigidity become insufficient, and when it exceeds 300  $\mu\text{m}$ , the laminated foam can lose its lightness and the closed cell ratio of the foam can decrease. The Y is preferably  
20        100~250  $\mu\text{m}$ , even more preferably, 130~250  $\mu\text{m}$ .

      Furthermore, when the density, d, of the foam is less than 100 g/L, it is too low and physical strength such as rigidity and compressive strength of the laminated foam can be lost. On the other hand, when it is above 300 g/L, the  
25        lightness of the laminated foam can be lost. The density, d, of the foam sheet is preferably 120 to 300 g/L.



The outermost resin layer in the laminated foam in accordance with present invention has a thickness of 5~80  $\mu\text{m}$ . Even when expensive functional additives such as polymer-type antistatic agents or fungicides are contained in the laminated foam having such structure, if they are incorporated in a minimum quantity only in the outermost layer, the concentration required for the additives to produce their effect can be obtained and the anticipated function can be demonstrated even with a small amount of additives. As a result, a sufficient effect can be obtained even when the functional additives are used in small amounts.

When a single resin layer is laminated on the foam, the addition of functional additives often decreases the MFR of the resin constituting the resin layer, or it is often necessary to decrease the MFR of the resin constituting the resin layer to which the functional additives are added, for example, because the functional additives cannot be effective due to kneadability of the resin with the additives. In such a case, the closed cell ratio of the foam is decreased. However, since the laminated foam in accordance with present invention has multiple resin layers, the above-mentioned situations can be avoided by adding the additives only to the outermost resin layer.

Measurement of MFR, as referred to in the present specification, is conducted at a test temperature of 230°C

under a load of 21.18N according to method A of JIS-K7210 (1999), regardless of the type of the base resin.

The thickness of resin layers and the thickness of the laminated foam, as referred to in the present specification, can be determined by taking pictures in ten equidistant points under a microscope of a section across the width of the laminated foam perpendicular to the extrusion direction of the foam, measuring the thickness based on the photographs, and averaging the results. However, when the interfaces between the resin layers are not clearly defined, the thickness can be determined based on the ratio of discharge rates of the layers in coextrusion process.

The density of foam sheet, as referred to in the present specification, is determined by cutting the foam sheet from the laminated foam and dividing the weight (g) of the cut sample by the volume (L) determined from the outer dimensions of the sample.

Because the laminated foam in accordance with the present invention has the above-described structure, it is possible to obtain laminated foams with physical properties within a wide range by appropriately selecting the combination of the type of the base resin, thickness, and density in the foam, outermost resin layer, innermost resin layer, and other resin layers.

The laminated foam in accordance with the present invention preferably has a thickness of 2 to 10 mm, even more preferably, 3 to 8 mm. If the thickness of the entire

laminated foam is less than 2 mm, the wall thickness of boxes, containers, and the like obtained by processing the laminated foam is insufficient, and their strength, heat resistance, and impact resistance are decreased. On the other hand, if the thickness of the entire laminated foam is more than 10 mm, then its bendability, e.g., in hinging, and processability in molding of containers, and the like can be decreased.

The foam constituting the laminated foam in accordance with the present invention can be manufactured by an extrusion foaming method. Multiple polyolefin layers are laminated on and bonded to the foam sheet or board by a coextrusion method when the foam sheet or board is manufactured by the extrusion foaming method. The utilization of the coextrusion method is also preferred from the standpoint of forming the outermost resin layer with a thickness of 5-80  $\mu\text{m}$ .

Manufacture of the foam in accordance with the present invention by the extrusion foaming method will be described below in greater detail. The foam can be obtained by melting a base resin in an extruder, while kneading it with a foaming agent, and then extruding and foaming the molten blend into a low-pressure region through a die installed at the front end of the extruder. A sheet-like foam is preferably obtained by a method comprising the steps of using a circular die having a ring-like lip, extruding and foaming through the lip of the die to obtain a tubular foam,

and then cut opening the tube to obtain a sheet. The cut-opened sheet-like foam is preferably subjected to hot stretching to obtain excellent smoothness, as described in Japanese Patent Application Laid-open No. H11-277696 and by  
5 this method, the sheet-like foam becomes the board-like foam. The sheet or board like foam can be also manufactured by extrusion through a flat die such as T-die, instead of the circular die.

The base resin constituting the foam in accordance  
10 with the present invention is a polyolefin. Examples of polyolefins include polypropylenes and polyethylenes. Polyolefins have extreme flexibility, have excellent physical strength, such as tensile strength, and good chemical resistance, and are suitable for extrusion foaming.  
15 For this reason they are excellent materials as the base resin constituting the foam in accordance with the present invention. Polypropylenes having especially high rigidity and heat resistance among the polyolefins are preferably used in accordance with the present invention.

20 Examples of the polypropylenes include propylene homopolymers or copolymers of propylene with other copolymerizable olefins. Examples of other copolymer components which are copolymerizable with propylene include ethylene or C<sub>4-10</sub>  $\alpha$ -olefins such as ethylene, 1-butene,  
25 isobutylene, 1-pentene, 3-methyl-1-butene, 1-hexene, 3,4-dimethyl-1-butene, 1-heptene, and 3-methyl-1-hexene. The copolymer may be a random copolymer or a block copolymer.

Further, the copolymer may consist not only of two, but also of three monomers. Moreover, the polypropylenes can be used individually or in a mixture of two or more thereof.

Even among the above-mentioned polypropylenes, a  
5 polypropylene with a melt tension higher than that of the ordinary polypropylenes is preferred as the resin suitable for extrusion foaming. Specific examples of preferred polypropylenes include (1) a polypropylene having a  
10 branching index of less than 1 and a significant strain hardening elongation viscosity, or (2) a polypropylene with (a) a z-average molecular weight ( $M_z$ ) of no less than  $1.0 \times 10^6$  or a ratio ( $M_z/M_w$ ) of the z-average molecular weight ( $M_z$ ) to weight-average molecular weight ( $M_w$ ) of no less than 3.0 and (b) either an equilibrium compliance  $J_e$  of no  
15 less than  $1.2 \times 10^{-3} \text{ m}^2/\text{N}$  or a shear strain recovery  $S_r/S$  per unit stress of no less than  $5 \times 10^{-4} \text{ m}^2$  per second, as described in Japanese Patent Application Laid-open No. H7-53797.

Other examples of polypropylenes that may be used in  
20 accordance with the present invention include: (3) polypropylenes modified by melt kneading a blend containing a radical polymerization monomer such as styrene and a radical polymerization initiator or additives at a temperature at which the polypropylene is melted and which  
25 is no less than the reaction temperature of the radical polymerization initiator, and (4) modified polypropylenes

obtained by melt kneading a polypropylene with an isoprene monomer and a radical polymerization initiator.

Preferred among the above-described base resins are those which have a low ratio of insoluble components into  
5 xylene.

The ratio of insoluble components is determined by the formula presented below by using a polypropylene or a foam thereof that has been accurately weighed as a sample, placing the sample into boiling xylene at a temperature of  
10 around 140°C, heating and refluxing for 8 hours, then rapidly filtering through a 100-mesh metal net, drying the components insoluble in boiling xylene that remained on the metal net for 24 hours in an oven at a temperature of 20°C, and then measuring the weight G (g) of insoluble components.  
15 The ratio of insoluble components is preferably 0 to 10 wt.%, more preferably, 0 to 5 wt.%, even more preferably, 0 to 2 wt.%. Resins with a low ratio of insoluble components can be easily recycled and are preferred from the standpoint of cost reduction.

20

Ratio of insoluble components (wt.%) =  $[G(g)/\text{sample weight (g)}] \times 100$ .

In accordance with the present invention, a blend prepared by mixing, if necessary, of a polypropylene with  
25 other resins can be used as the base resin constituting the above-mentioned foam sheet. Examples of such other resins include elastomers such as ethylene-propylene rubbers or

ionomers, polyethylenes, polybutenes, vinyl chloride resins such as poly(vinyl chloride), vinyl chloride - vinyl acetate copolymer, and the like, polystyrenes, and the like. When such other resins are admixed, the mixing ratio

5 thereof is preferably no more than 40 wt.% based on the total weight of the base resin.

When the base resin of the foam in accordance with the present invention is composed of polyethylenes, examples of such polyethylenes include compositions containing no less  
10 than 60 wt.% ethylene homopolymer and copolymers of ethylene and  $\alpha$ -olefins containing 3 to 12 carbon atoms. Specific examples include high-density polyethylene, medium-density polyethylene, low-density polyethylene, straight-chain low-density polyethylene, straight-chain  
15 ultralow-density polyethylene, ethylene - vinyl acetate copolymer, ethylene - butene copolymer, ethylene - maleic anhydride copolymer, and the like. Therefore, the base resin of the foam can be composed of a blend of a polyethylene with other resins.

20 Furthermore, the base resin of the foam in accordance with the present invention can be composed of a mixed resin of a polypropylene and a polyethylene.

Inorganic foaming agents and volatile foaming agents can be used for the manufacture of the foam in accordance  
25 with the present invention. Examples of inorganic foaming agents include carbon dioxide, air, and nitrogen. Examples of volatile foaming agents include aliphatic hydrocarbons

such as propane, n-butane, i-butane, pentane, hexane, and the like, ethers such as dimethylether, methylethylether, diethylether, and the like. Those foaming agents can be also used in appropriate mixtures thereof.

5 Furthermore, if necessary, various additives can be added to the base resin so that the foam in accordance with the present invention may manufacture it. Examples of additives include nucleating agents, e.g., inorganic powders such as talc, silica, and the like, or acidic salts  
10 of polycarboxylic acids, reaction products of polycarboxylic acids with sodium carbonate or sodium bicarbonate, and the like, inorganic fillers such as talc, silica, calcium carbonate, clay, zeolites, alumina, barium sulfate, and the like (talc and silica also serve as  
15 nucleating agents), thermal stabilizers, UV absorbers, antioxidants, colorants, and the like. Antistatic agents and fungicides may be also blended.

The closed cell ratio of the laminated foam in accordance with the present invention is preferably no less  
20 than at least 60%, even more preferably, no less than 70%, and still more preferably, no less than 80%. If the closed cell ratio is less than 60%, then bending strength or compressive strength of the laminated foam decreases and, for example, physical strength containers, and the like  
25 obtained by processing the laminated foam decreases, and they have the possibility that they cannot be used as goods-delivery boxes or harvest containers.



The closed cell ratio S (%) of the laminated foam, as referred to in the present specification, is calculated by the following formula (6) from the true volume Vx of laminated foam measured according to procedure C described in ASTM D2856-70 by using Air Comparison Pycnometer 930 manufactured by Toshiba Beckman Co., Ltd.

$$S(\%) = (Vx - W/\rho) \times 100 / (Va - W/\rho) \dots (6)$$

In formula (6), Vx stands for a true volume (cm<sup>3</sup>) measured by the above-mentioned method, which is equivalent to a sum of the volume of the resin constituting the laminated foam and the total volume of cells in the closed cell portion inside the laminated foam. Further, Va, W, and ρ in formula (6) are described below.

Va : apparent volume of the laminated foam calculated from the external dimensions of the laminated foam used for the measurements (cm<sup>3</sup>).

W : total weight of the laminated foam used for the measurements (g).

ρ : density of the resin constituting the laminated foam used for the measurements (g/cm<sup>3</sup>).

The density ρ of the resin constituting the laminated foam used for the measurements can be determined from the sample prepared by collapsing the cells in the laminated foam with a heat press.

Since the sample has to be contained in a non-compressed state in the sample cup provided in the air comparison pycnometer, the sample is cut to a length and a width of 2.5 cm each and a height of 4 cm so as to have an apparent volume of 25 cm<sup>3</sup>. When the thickness of the laminated foam is less than 4 cm, several samples for measurements that have been cut from the laminated foam are combined so as to obtain a volume most close to 25 cm<sup>3</sup>, and this combination is used as a sample.

10 Polyolefins such as polypropylenes or polyethylenes of the same type which demonstrate sufficient ability of thermal bonding to the foam are used as the base resins constituting the innermost resin layer of the polyolefin layers in the laminated foam in accordance with the present invention. Further, the outermost resin layer prefers to show sufficient ability of thermal bonding to the inner resin layer. In addition, other resin layers such as layers of polyamide resins, vinylidene chloride resin, and saponified ethylene - vinyl acetate copolymer having a gas barrier function can be provided, if necessary, between the outermost resin layer and innermost resin layer via an adhesive. Moreover, a layer comprising recycled starting materials can be used as the innermost resin layer in order to obtain an inexpensive laminated foam.

25 One or more types of additives such as polymer-type antistatic agents, fungicides, elastomers, and the like can be added to the base resin constituting the outermost resin

layer of the laminated foam in accordance with the present invention in order to obtain a more functional laminated foam in accordance with the present invention.

Polyolefins typically have a surface resistivity of  $1 \times 10^{16}$  to  $1 \times 10^{20} \Omega$ . When the surface resistivity exceeds  $1 \times 10^{13} \Omega$ , static charges are accumulated on the surface of the laminated foam and dust easily adheres thereto.

Accordingly, in order to provide the surface with antistatic properties, a surfactant with a low molecular weight, such as a partial ester of glycerin (for example, glycerin monostearate) is kneaded into the polyolefin. In this case, however, the antistatic effect is not demonstrated unless the surfactant is present on the surface. Therefore, when a surfactant with a low molecular weight was used in the manufacture of polyolefin foams, a respective time was required before the antistatic effect was demonstrated, and no antistatic effect was demonstrated unless the above-described surfactant incorporated moisture present in the air. Therefore, a problem associated with such manufacturing process was that the antistatic effect was greatly affected by the season or the environment in which the foam was used, and the desired antistatic effect was sometimes not produced.

Furthermore, if the foam having the above-mentioned surfactant added thereto is washed with water and a detergent, the surfactant is washed out and the antistatic effect is lost. For this reason, goods-delivery boxes using

the foam having such surfactant added thereto are difficult to wash and reuse and they are hardly suitable for returnable usage in applications adversely affected by static charges or dust.

5       A polymer-type antistatic agent is preferably used in the laminated foam in accordance with the present invention in order to provide the laminated foam with antistatic properties. The laminated foam obtained by incorporating such antistatic agent in the polyolefin constituting the  
10       outermost resin layer of the laminated foam in accordance with the present invention demonstrates a sufficient antistatic effect immediately after molding and the antistatic effect is not lost in washing. On the other hand, polymer-type antistatic agents are very expensive and in  
15       order to manufacture an inexpensive product, it is desired that a sufficient effect be demonstrated at a small amount of the antistatic agent. In the laminated foam in accordance with the present invention, the outermost resin layer is formed so as to have a small thickness. Therefore,  
20       blending the polymer type antistatic agent only into the outermost resin layer of the laminated foam in accordance with the present invention makes it possible to demonstrate a sufficient antistatic effect with a small absolute amount of the antistatic agent. It is desired that the outermost  
25       resin layer in the laminated foam in accordance with the present invention be formed as thin as possible within a range in which the anticipated characteristic properties

provided for by the addition of functional additives are not lost. Typically, the outermost resin layer is formed to have a thickness of 5~80  $\mu\text{m}$ , preferably, 10~50  $\mu\text{m}$ .

If the polymer-type antistatic agent is simply blended with the polyolefin, the antistatic effect is not fully demonstrated. Apparently, the antistatic effect cannot be demonstrated unless the antistatic agent is arranged on the resin layer surface in a state in which it is dispersed in a vein-like manner and forms a continuous layer on the surface of the polyolefin layer forming the outermost resin layer (such state is referred to as a network structure hereinbelow). Such a network structure is easily formed by providing an appropriate orientation when the outermost surface layer is formed.

In accordance with the present invention, the above-described polymer-type antistatic agent is incorporated into the polyolefin constituting the outermost resin layer so that the surface resistivity of the outermost surface layer is no more than  $1 \times 10^{13} \Omega$ , preferably, no more than  $1 \times 10^{12} \Omega$ , even more preferably, no more than  $1 \times 10^{11} \Omega$ . No limitation is placed on the lower limit of the surface resistivity of the outermost surface layer controlled by the addition of the polymer-type antistatic agent; usually it is  $1 \times 10^8 \Omega$ .

The surface resistivity as referred to in the present specification is measured according to JIS-K6911.

More specifically, three samples (length : 100 mm, width : 100 mm, thickness : sample thickness) are cut equidistantly from the obtained laminated foam in the lateral direction thereof perpendicular to the extrusion direction of the foam. The samples are allowed to stay for 24 hours in an atmosphere with a temperature of 23°C and a humidity of 50%. Then, the surface resistance of the samples is measured. The average value of the measurement results is considered as a surface resistivity.

In the present specification, the term polymer-type antistatic agent means a resin with a number-average molecular weight of at least no less than 300, preferably, 300 to 300,000, even more preferably, 600 to 15,000, and with a surface resistivity of less than  $1 \times 10^{12} \Omega$ , preferably less than  $1 \times 10^9 \Omega$ . Furthermore, the polymer-type antistatic agent as referred to in the present specification may contain inorganic salts or organic protonic acid salts with a low molecular weight, for example,  $\text{LiClO}_4$ ,  $\text{LiCF}_3\text{SO}_3$ ,  $\text{NaClO}_4$ ,  $\text{LiBF}_4$ ,  $\text{NaBF}_4$ ,  $\text{KBF}_4$ ,  $\text{KClO}_4$ ,  $\text{KPF}_3\text{SO}_3$ ,  $\text{Ca}(\text{ClO}_4)_2$ ,  $\text{Mg}(\text{ClO}_4)_2$ ,  $\text{Zn}(\text{ClO}_4)_2$ , and the like. The upper limit for the molecular weight of the polymer-type antistatic agent is about 500,000.

The above-mentioned molecular weight is a number-average molecular weight obtained by employing gel permeation chromatography and using a calibration curve plotted for polystyrene with a known molecular weight.

The upper limit for the melting point of the polymer-type antistatic agent is about 270°C and the lower limit is about 70°C.

Specific examples of the polymer-type antistatic agent, as referred to in the present specification, include resins, such as polyethylene oxide, polypropylene oxide, polyethylene glycol, polyethers, polyesteramides, polyetheresteramides, ionomer such as ethylene - methacrylic acid copolymer, and the like, polyethylene glycol methacrylate polymers, and the like, that have a polar group in a molecular chain in a quaternary ammonium salt and can form complexes or solvate with inorganic salts or organic protonic acid salts with a low molecular weight. Above-described resins that have formed complexes or solvated with the inorganic salts or organic protonic acid salts may also be used.

Agents containing polyetheresteramides or polyethers as the main components are especially preferred among the above-described polymer-type antistatic agents used in accordance with the present invention. Such antistatic agents can demonstrate an excellent antistatic performance, regardless of the value of the ratio of the melt flow rate of the base resin of the outermost resin layer and the melt flow rate of the antistatic agent. Furthermore, in order to improve compatibility of such antistatic agents with the polyolefin constituting the outermost resin layer, obtain an excellent antistatic effect, and suppress the

degradation of physical properties, it is preferred that the polyolefin of the same type be copolymerized or mixed with the polymer-type antistatic agents. In the present specification, the term "as the main component" used

5 hereinabove means that the polyetheresteramide component or polyether component is contained at a ratio of no less than 50 wt.%, preferably, no less than 75 wt.%, even more preferably, no less than 85 wt.%. Using such antistatic agents and forming a network structure of the polymer-type  
10 antistatic agent in the outermost resin layer by the extrusion method makes it possible to form easily the outermost resin layer with a surface resistivity of no more than  $1 \times 10^{13} \Omega$ .

The aforesaid polyetheresteramides of the antistatic  
15 agent, as referred to in the present specification, are obtained by polymerization of polyamides (1) listed hereinbelow and alkylene oxide adducts of bisphenols (2).

Examples of polyamides (1) include: (a) polymers obtained by lactam ring-opening polymerization, (b)  
20 polycondensates of aminocarboxylic acids, or (c) polycondensates of dicarboxylic acids and diamines. Examples of lactams mentioned in (a) include caprolactam, enantholactam, laurolactam, undecalactam, and the like.

Examples of aminocarboxylic acids mentioned in (b)  
25 include  $\omega$ -aminocaproic acid,  $\omega$ -aminoenanthic acid,  $\omega$ -aminocaprylic acid,  $\omega$ -aminopelargonic acid,  $\omega$ -aminocapric



acid, 11-aminoundecanoic acid, 12-aminododecanoic acid, and the like.

Examples of dicarboxylic acids mentioned in (c) include adipic acid, azelaic acid, sebacic acid, 5 undecanedioic acid, dodecanedioic acid, isophthalic acid, and the like. Examples of diamines include hexamethylenediamine, heptamethylenediamine, octamethylenediamine, decamethylenediamine, and the like.

Among the amido-forming monomers listed above, 10 monomers of two or more types may be used. The preferred among them are caprolactam, 12-aminododecanoic acid, and adipic acid - hexamethylenediamine, and the especially preferred is caprolactam.

Examples of bisphenols in the aforesaid alkylene oxide 15 adducts of bisphenols (2) include bisphenol A (4,4'-dihydroxydiphenyl-2,2-propane), bisphenol F (4,4'-dihydroxydiphenylmethane), bisphenol S (4,4'-dihydroxydiphenylsulfone), 4,4'-dihydroxydiphenyl-2,2-butane, and the like. Among them, bisphenol A is especially 20 preferred.

Examples of alkylene oxides in the aforesaid alkylene oxide adducts of bisphenols (2) include ethylene oxide, propylene oxide, 1,2- or 1,4-butylene oxide, and mixtures of two or more thereof. Among them, ethylene oxide is 25 preferred.

In accordance with the present invention, the melting point of the polyetheresteramide contained in the outermost

resin layer is preferably no higher than 230°C, more preferably, no higher than 200°C. If the melting point is above 230°C, when the polyolefin is melted and mixed together with the polyetheresteramide, the temperature of the two resins has to be increased above the necessary level, which can cause degradation of the polyolefin.

Examples of polyethers as the aforesaid antistatic agents, as referred to in the present specification, include cationic antistatic agents consisting of compounds

having no less than 2 quaternary ammonium bases in a molecule, those compounds being the reaction products of (a) oxyalkylene ethers obtained by addition reaction of alkylene oxides with phenols - divinyl benzene addition polymers, (b) glycidyl ethers of polyoxyalkylene glycols such as polyoxyethylene glycol, polyoxypropylene glycol, polyoxybutylene glycol, and the like or diglycidyl ethers of alkylene oxide adducts of bisphenols, amine compounds having aliphatic hydrocarbon groups containing 1 to 22 carbon atoms, preferably, amine compounds having aliphatic hydrocarbon groups containing 6 to 22 carbon atoms, such as hexyl, n-octyl, 2-ethylhexyl, nonyl, decyl, dodecyl, tetradecyl, octadecyl, oleyl, and the like, and quaternizing agents such as alkyl esters of sulfuric acid, such as dimethyl sulfate, diethyl sulfate, and the like, alkyl esters of carbonic acid, such as dimethyl carbonate, diethyl carbonate, and the like, and various phosphates or halides such as trimethyl phosphate, alkylbenzyl chlorides,

benzyl chloride, alkyl chlorides, alkyl bromide, and the like.

Examples of the aforesaid alkylene oxides include ethylene oxide, propylene oxide, and butylene oxide; among  
5 them, ethylene oxide and a copolymer of ethylene oxide and propylene oxide are preferred. The number of added moles of alkylene oxide is usually 1 to 500, preferably, 20 to 300. The content ratio of oxyalkylene in the oxyalkylene ether is 10 to 95 wt.%, preferably, 20 to 90 wt.%, still more  
10 preferably, 30 to 80 wt.%.

Examples of bisphenols in the aforesaid alkylene oxide adducts of bisphenols include bisphenol A (4,4'-  
dihydroxydiphenyl-2,2-propane), bisphenol F (4,4'-  
dihydroxydiphenylmethane), bisphenol S (4,4'-  
15 dihydroxydiphenylsulfone), 4,4'-dihydroxydiphenyl-2,2-butane, and the like.

Among the above-mentioned diglycidyl ethers, examples of the especially preferred ones include glycidyl ether of polyoxyethylene glycol, diglycidyl ether of ethylene oxide  
20 adduct of bisphenol, and mixtures thereof.

Among the above-mentioned amine compounds, the especially preferred one is N-alkyl ( $C_{1-18}$ ) diethanolamine.

Among the above-mentioned quaternizing compounds, the especially preferred ones are dimethyl sulfate and diethyl  
25 sulfate.

The MFR,  $\alpha$  (g/10 min), of the polymer-type antistatic agent in the laminated foam in accordance with the present

invention is no less than 10 (g/10 min), preferably 10-150 (g/10 min), with the upper limit being about 500 (g/10 min). Furthermore, the MFR,  $\beta$  (g/10 min), of the base resin constituting the outermost layer is no less than 2 (g/10 min), preferably 3 to 35 (g/10 min), even more preferably, 8-35 (g/10 min), the upper limit preferably being no more than 40 (g/10 min). The ratio ( $\alpha/\beta$ ) of the MFR,  $\alpha$ , of the polymer-type antistatic agent and MFR,  $\beta$ , of the base resin constituting the outermost layer is preferably no less than at least 0.5, more preferably 1-250, and still more preferably 1-150. When the polymer-type antistatic agent is an ionomer-type antistatic agent, the ratio ( $\alpha/\beta$ ) of the MFR,  $\alpha$  (g/10 min), of the polymer-type antistatic agent and MFR,  $\beta$  (g/10 min), of the base resin constituting the outermost layer should be no less than at least 2.5 for the antistatic agent to form a network structure in the outermost resin layer and to demonstrate sufficient antistatic properties.

In order to increase compatibility with the polyolefin constituting the outermost resin layer and to obtain excellent antistatic effect and excellent effect suppressing the degradation of physical properties, a compound prepared by copolymerizing the polyolefins of the same type, preferably, a modified polyolefin with a number-average molecular weight of 800 to 25,000 or a polyamide with a polymer-type antistatic agent, or a mixture thereof is used as the polyetheresteramide or polyether preferably

employed in accordance with the present invention. Examples of polyamides suitable for this purpose include polyamide 4, polyamide 6, polyamide 11, polyamide 12, polyamides 6/6, 6/10, 6/9, 6/12, 4/6, 12/12, aromatic polyamide of m-

5 xylenediamine and adipic acid, polyamides obtained from hexamethylenediamine and isophthalic acid and/or terephthalic acid with the addition, if necessary, of an elastomer, or copolymers of those polyamides with polyolefins, olefin copolymers, ionomers, elastomers, 10 polyethylene glycol, polypropylene glycol, or polytetramethylene glycol, EPDM or ABS-modified polyamides or copolyamides, and the like.

Those polyolefins or polyamides are compounded so that the content ratio of the polyetheresteramide or polyether 15 of the polymer-type antistatic agent, as described above, is at least 50 wt.%, preferably, 75 wt.%, still more preferably, 85 wt.%.

The amount of the polymer-type antistatic agent added to the outermost resin layer in the laminated foam in 20 accordance with the present invention is preferably 2 to 30 wt.%, still more preferably, 5 to 25 wt.%, and even more preferably, 10 to 20 wt.%. When the amount added is less than 2 wt.%, the antistatic effect can be insufficient. If it is above 30 wt.%, physical properties of the outermost 25 resin layer can be degraded or the outermost resin layer itself can be difficult to make and the inexpensive laminated foam is difficult to manufacture.

The laminated foam (especially, in the outermost resin layer) in accordance with the present invention, if desired, can be provided with bactericidal properties. Examples of fungicides that can be used in accordance with the present invention include inorganic fungicides such as metals (ions) having bactericidal activity, such as silver, copper, zinc, and the like, which are supported on a support, for example, silver zeolite, copper zeolite, silver-supporting zirconium phosphate, silver-supporting silica gel, and the like, fungicides using oxide-based photocatalysts such as anatase-type titanium oxide, and organic fungicides such as benzalkonium chlorides, polyoxyethylene trialkyl ammonium chlorides, polyhexamethylene biguanido hydrochloride, 3-(trimethoxysilyl) propyldimethyloctadecyl ammonium chloride, and the like.

In the laminated polyolefin foam in accordance with the present invention, in which multiple layers of polyolefin are laminated on at least one side of a polyolefin foam, among the polyolefin layers laminated on and bonded to the foam, the thickness of the innermost resin layer is 70~300  $\mu\text{m}$ , the MFR of the base resin constituting the innermost resin layer is 5~40 g/10 min, and the density of the foam is 100~300 g/L. When those layers satisfy the above-described specific conditions, resin layers of sufficient thickness can be formed on the foam, without decreasing the closed cell ratio of the foam, and a laminated foam is obtained which has an especially

good physical strength such as bending strength.

Furthermore, because mixing of additives, which make fluidity decline, decreases MFR and causes the decrease in the closed cell ratio of the foam, forming a polyolefin

5 layer with a thickness of 5-80  $\mu\text{m}$  as the outermost resin layer makes it possible to provide a resin layer which is difficult to laminate and bond directly to the foam.

Moreover, sufficient results are obtained by the addition of the expensive additives only to a thin outermost resin  
10 layer, the target effect can be fully demonstrated without the addition of large quantities of additives, and a laminated foam is provided with functional properties at a low cost. It is preferred that the thickness of the outermost resin layer be less than that of the innermost  
15 resin layer.

#### Example

The present invention will be described below in  
20 greater details based on examples thereof which, however, place no limitation on the present invention.

Polyolefins and polymer-type antistatic agents that were used in examples and comparative examples are presented below. In the examples and comparative examples,  
25 the melt flow rate is represented by MFR.

#### (I) Polyolefins

Resin I : GRAND POLYMER CO., LTD. Trade name J704U

(propylene - ethylene block copolymer) (MFR : 5 g/10 min)

5 Resin II : SunAllomer Ltd., recovered starting materials of  
trade name SD632 (polypropylene) (MFR : 10 g/10 min).

Resin III : SunAllomer Ltd., trade name PM870A (propylene -  
ethylene block copolymer) (MFR : 17 g/10 min).

10 Resin IV : Idemitsu Petrochemical Co., Ltd., trade name  
J950HP (propylene - ethylene block copolymer) (MFR : 32  
g/10 min).

Resin V : Idemitsu Petrochemical Co., Ltd., trade name  
E200GP (propylene homopolymer) (MFR : 2 g/10 min).

Resin VI : SunAllomer Ltd., trade name SD632  
(polypropylene) (MFR : 3.2 g/10 min).

15 Resin VII : NIPPON UNICAR CO., LTD., trade name NUC8008  
(low-density polyethylene) (MFR : 9.6 g/10 min).

Resin VIII: Idemitsu Petrochemical Co., Ltd., trade name  
130J (high-density polyethylene) (MFR : 20 g/10 min).

## 20 (II) Polymer-type antistatic agents

Polymer A : Ciba Specialty Chemicals K. K., trade name  
IRGASTAT P 18 (a polymer-type antistatic agent containing  
polyetheresteramide as the main component) (MFR : 17 g/10  
25 min, melting point : 180°C).

Polymer B : Ciba Specialty Chemicals K. K., trade name  
IRGASTAT P 22 (polymer-type antistatic agent containing



polyetheresteramide as the main component) (MFR : 21 g/10 min, melting point : 220°C).

Polymer C : Sanyo Chemical Industries, Ltd., trade name J-STAT 3180 (polymer-type antistatic agent containing

5 polyetheresteramide as the main component) (MFR : 70 g/10 min, melting point 160°C).

Polymer D : DU PONT - MITSUI POLYCHEMICALS CO., LTD., trade name SD100 (polymer-type antistatic agent containing ethylene-based ionomer as the main component) (MFR : 20  
10 g/10 min, melting point : 92°C).

Polymer E : Sanyo Chemical Industries, Ltd., trade name PELESTAT 300 (polymer-type antistatic agent containing polyether as the main component), (MFR : no less than 100  
15 g/10 min, melting point 136°C).

The melting point of resins, as referred to in the present specification, is a melting point measured according to JIS K7121-1987. When no less than two peaks are observed in the DSC curve, the apex temperature of the  
20 peak with the largest surface area is considered as the melting point.

#### Example 1

25 A tandem extruder consisting of two extruders with diameters of 90 mm and 120 mm was used as the apparatus for the manufacture of the foam of the laminated foam. An

extruder with a diameter of 50 mm was used for molding the innermost resin layer, and an extruder with a diameter of 40 mm was used for molding the outermost resin layer. A ring-like die with a diameter of 140 mm and a spacing of 1.0 mm was used as a coextrusion die for obtaining a laminated foam in which the innermost resin layer and the outermost resin layer were laminated on and bonded to the foam.

First, in order to obtain the foam, 100 wt. parts of polypropylene resin (resin VI) and 0.5 wt. part of nucleating agent (prepared by blending 6 wt. parts of sodium citrate with 100 wt. parts of low-density polyethylene with a melting point of 109°C and a MFR of 5.4 g/10 min) were fed from a starting material charging hopper of the extruder with a diameter of 90 mm, and the components were heated and kneaded to obtain a melted resin mixture with a temperature of about 200°C. A mixed foaming agent consisting of n-butane 70 wt.% and i-butane 30 wt.% was injected into the melted resin mixture so as to obtain 1.2 wt. part of the foaming agent per 100 wt. parts of resin VI. Then, the melted resin mixture containing the foaming agent was fed into the extruder with a diameter of 120 mm that was connected downstream of the extruder with a diameter of 90 mm, the viscosity of the melted resin was adjusted, and a foamable melted resin mixture was obtained.

On the other hand, resins shown in Table 2 which constitute the innermost resin layer were fed into an

extruder with a diameter of 50 mm where they were melt kneaded to obtain a melted resin. A resin mixture of an antistatic agent and resins shown in Table 2 which constitute the outermost resin layer was melt kneaded with an extruder with a diameter of 40 mm to obtain a melted resin containing an antistatic agent. The obtained foamable melted resin mixture, melted resin, and melted resin containing an antistatic agent were fed in a convergent die. The antistatic agent-containing melted resin forming the outermost resin layer, the melted resin forming the innermost resin layer, and the foamable melted resin mixture were laminated, converged, and coextruded from a ring-like die to form a tubular laminated foam in which layers were laminated in the following order from the outer side: outermost resin layer/innermost resin layer/foam/innermost resin layer/outermost resin layer. The extruded tubular laminated foam was cut and opened, while being drawn along a cooled cylinder, and then both surfaces of the laminated foam were heated in a heating furnace while being pulled to flatten it and obtain the target laminated foam board.

Table 2 shows the types, melt flow rate (MFR), and layer thickness of resins constituting the innermost and outermost resin layers of the laminated foam. The MFR : X and thickness : Y of the polyolefin composition constituting the innermost resin layer, the thickness (mm), closed cell ratio (%), and surface resistivity( $\Omega$ ) of the

laminated foam, and the density:  $d$  (g/L) of the foam are presented in Table 1.

Examples 2 to 10, Comparative Examples 1, 2

5

The laminated foams were obtained in the same manner as in Example 1, except that the amount of the foaming agent added was 2.8 wt. parts per 100 wt. parts of resin VI; all other conditions are presented in Table 2. Physical properties of the laminated foams obtained in the same manner as in Example 1 are presented in Table 1 and Table 2.

Examples 11, 12

The laminated foams were obtained in the same manner as in Example 1, except those parameters shown in Table 2 and that resin VII was used as the base resin of the foam, the amount of the nucleating agent was 0.3 wt. part and the amount of the foaming agent was 2.1 wt. part. Physical properties of the laminated foams obtained in the same manner as in Example 1 are presented in Table 1 and Table 2. The mixing weight ratio of resins VII and VIII constituting the innermost resin layer and outermost resin layer was 70 : 30.

Comparative Example 3

The laminated foam was obtained in the same manner as in Example 1, except that the amount of the foaming agent added was 3.0 wt. parts; all other conditions are presented in Table 2. Physical properties of the laminated foams  
5 obtained in the same manner as in Example 1 are presented in Table 1 and Table 2.

11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65  
66  
67  
68  
69  
70  
71  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81  
82  
83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99  
100  
101  
102  
103  
104  
105  
106  
107  
108  
109  
110  
111  
112  
113  
114  
115  
116  
117  
118  
119  
120  
121  
122  
123  
124  
125  
126  
127  
128  
129  
130  
131  
132  
133  
134  
135  
136  
137  
138  
139  
140  
141  
142  
143  
144  
145  
146  
147  
148  
149  
150  
151  
152  
153  
154  
155  
156  
157  
158  
159  
160  
161  
162  
163  
164  
165  
166  
167  
168  
169  
170  
171  
172  
173  
174  
175  
176  
177  
178  
179  
180  
181  
182  
183  
184  
185  
186  
187  
188  
189  
190  
191  
192  
193  
194  
195  
196  
197  
198  
199  
200  
201  
202  
203  
204  
205  
206  
207  
208  
209  
210  
211  
212  
213  
214  
215  
216  
217  
218  
219  
220  
221  
222  
223  
224  
225  
226  
227  
228  
229  
230  
231  
232  
233  
234  
235  
236  
237  
238  
239  
240  
241  
242  
243  
244  
245  
246  
247  
248  
249  
250  
251  
252  
253  
254  
255  
256  
257  
258  
259  
260  
261  
262  
263  
264  
265  
266  
267  
268  
269  
270  
271  
272  
273  
274  
275  
276  
277  
278  
279  
280  
281  
282  
283  
284  
285  
286  
287  
288  
289  
290  
291  
292  
293  
294  
295  
296  
297  
298  
299  
300  
301  
302  
303  
304  
305  
306  
307  
308  
309  
310  
311  
312  
313  
314  
315  
316  
317  
318  
319  
320  
321  
322  
323  
324  
325  
326  
327  
328  
329  
330  
331  
332  
333  
334  
335  
336  
337  
338  
339  
340  
341  
342  
343  
344  
345  
346  
347  
348  
349  
350  
351  
352  
353  
354  
355  
356  
357  
358  
359  
360  
361  
362  
363  
364  
365  
366  
367  
368  
369  
370  
371  
372  
373  
374  
375  
376  
377  
378  
379  
380  
381  
382  
383  
384  
385  
386  
387  
388  
389  
390  
391  
392  
393  
394  
395  
396  
397  
398  
399  
400  
401  
402  
403  
404  
405  
406  
407  
408  
409  
410  
411  
412  
413  
414  
415  
416  
417  
418  
419  
420  
421  
422  
423  
424  
425  
426  
427  
428  
429  
430  
431  
432  
433  
434  
435  
436  
437  
438  
439  
440  
441  
442  
443  
444  
445  
446  
447  
448  
449  
450  
451  
452  
453  
454  
455  
456  
457  
458  
459  
460  
461  
462  
463  
464  
465  
466  
467  
468  
469  
470  
471  
472  
473  
474  
475  
476  
477  
478  
479  
480  
481  
482  
483  
484  
485  
486  
487  
488  
489  
490  
491  
492  
493  
494  
495  
496  
497  
498  
499  
500  
501  
502  
503  
504  
505  
506  
507  
508  
509  
510  
511  
512  
513  
514  
515  
516  
517  
518  
519  
520  
521  
522  
523  
524  
525  
526  
527  
528  
529  
530  
531  
532  
533  
534  
535  
536  
537  
538  
539  
540  
541  
542  
543  
544  
545  
546  
547  
548  
549  
550  
551  
552  
553  
554  
555  
556  
557  
558  
559  
560  
561  
562  
563  
564  
565  
566  
567  
568  
569  
570  
571  
572  
573  
574  
575  
576  
577  
578  
579  
580  
581  
582  
583  
584  
585  
586  
587  
588  
589  
590  
591  
592  
593  
594  
595  
596  
597  
598  
599  
600  
601  
602  
603  
604  
605  
606  
607  
608  
609  
610  
611  
612  
613  
614  
615  
616  
617  
618  
619  
620  
621  
622  
623  
624  
625  
626  
627  
628  
629  
630  
631  
632  
633  
634  
635  
636  
637  
638  
639  
640  
641  
642  
643  
644  
645  
646  
647  
648  
649  
650  
651  
652  
653  
654  
655  
656  
657  
658  
659  
660  
661  
662  
663  
664  
665  
666  
667  
668  
669  
670  
671  
672  
673  
674  
675  
676  
677  
678  
679  
680  
681  
682  
683  
684  
685  
686  
687  
688  
689  
690  
691  
692  
693  
694  
695  
696  
697  
698  
699  
700  
701  
702  
703  
704  
705  
706  
707  
708  
709  
710  
711  
712  
713  
714  
715  
716  
717  
718  
719  
720  
721  
722  
723  
724  
725  
726  
727  
728  
729  
730  
731  
732  
733  
734  
735  
736  
737  
738  
739  
740  
741  
742  
743  
744  
745  
746  
747  
748  
749  
750  
751  
752  
753  
754  
755  
756  
757  
758  
759  
760  
761  
762  
763  
764  
765  
766  
767  
768  
769  
770  
771  
772  
773  
774  
775  
776  
777  
778  
779  
780  
781  
782  
783  
784  
785  
786  
787  
788  
789  
790  
791  
792  
793  
794  
795  
796  
797  
798  
799  
800  
801  
802  
803  
804  
805  
806  
807  
808  
809  
810  
811  
812  
813  
814  
815  
816  
817  
818  
819  
820  
821  
822  
823  
824  
825  
826  
827  
828  
829  
830  
831  
832  
833  
834  
835  
836  
837  
838  
839  
840  
841  
842  
843  
844  
845  
846  
847  
848  
849  
850  
851  
852  
853  
854  
855  
856  
857  
858  
859  
860  
861  
862  
863  
864  
865  
866  
867  
868  
869  
870  
871  
872  
873  
874  
875  
876  
877  
878  
879  
880  
881  
882  
883  
884  
885  
886  
887  
888  
889  
890  
891  
892  
893  
894  
895  
896  
897  
898  
899  
900  
901  
902  
903  
904  
905  
906  
907  
908  
909  
910  
911  
912  
913  
914  
915  
916  
917  
918  
919  
920  
921  
922  
923  
924  
925  
926  
927  
928  
929  
930  
931  
932  
933  
934  
935  
936  
937  
938  
939  
940  
941  
942  
943  
944  
945  
946  
947  
948  
949  
950  
951  
952  
953  
954  
955  
956  
957  
958  
959  
960  
961  
962  
963  
964  
965  
966  
967  
968  
969  
970  
971  
972  
973  
974  
975  
976  
977  
978  
979  
980  
981  
982  
983  
984  
985  
986  
987  
988  
989  
990  
991  
992  
993  
994  
995  
996  
997  
998  
999  
1000  
1001  
1002  
1003  
1004  
1005  
1006  
1007  
1008  
1009  
1010  
1011  
1012  
1013  
1014  
1015  
1016  
1017  
1018  
1019  
1020  
1021  
1022  
1023  
1024  
1025  
1026  
1027  
1028  
1029  
1030  
1031  
1032  
1033  
1034  
1035  
1036  
1037  
1038  
1039  
1040  
1041  
1042  
1043  
1044  
1045  
1046  
1047  
1048  
1049  
1050  
1051  
1052  
1053  
1054  
1055  
1056  
1057  
1058  
1059  
1060  
1061  
1062  
1063  
1064  
1065  
1066  
1067  
1068  
1069  
1070  
1071  
1072  
1073  
1074  
1075  
1076  
1077  
1078  
1079  
1080  
1081  
1082  
1083  
1084  
1085  
1086  
1087  
1088  
1089  
1090  
1091  
1092  
1093  
1094  
1095  
1096  
1097  
1098  
1099  
1100  
1101  
1102  
1103  
1104  
1105  
1106  
1107  
1108  
1109  
1110  
1111  
1112  
1113  
1114  
1115  
1116  
1117  
1118  
1119  
1120  
1121  
1122  
1123  
1124  
1125  
1126  
1127  
1128  
1129  
1130  
1131  
1132  
1133  
1134  
1135  
1136  
1137  
1138  
1139  
1140  
1141  
1142  
1143  
1144  
1145  
1146  
1147  
1148  
1149  
1150  
1151  
1152  
1153  
1154  
1155  
1156  
1157  
1158  
1159  
1160  
1161  
1162  
1163  
1164  
1165  
1166  
1167  
1168  
1169  
1170  
1171  
1172  
1173  
1174  
1175  
1176  
1177  
1178  
1179  
1180  
1181  
1182  
1183  
1184  
1185  
1186  
1187  
1188  
1189  
1190  
1191  
1192  
1193  
1194  
1195  
1196  
1197  
1198  
1199  
1200  
1201  
1202  
1203  
1204  
1205  
1206  
1207  
1208  
1209  
1210  
1211  
1212  
1213  
1214  
1215  
1216  
1217  
1218  
1219  
1220  
1221  
1222  
1223  
1224  
1225  
1226  
1227  
1228  
1229  
1230  
1231  
1232  
1233  
1234  
1235  
1236  
1237  
1238  
1239  
1240  
1241  
1242  
1243  
1244  
1245  
1246  
1247  
1248  
1249  
1250  
1251  
1252  
1253  
1254  
1255  
1256  
1257  
1258  
1259  
1260  
1261  
1262  
1263  
1264  
1265  
1266  
1267  
1268  
1269  
1270  
1271  
1272  
1273  
1274  
1275  
1276  
1277  
1278  
1279  
1280  
1281  
1282  
1283  
1284  
1285  
1286  
1287  
1288  
1289  
1290  
1291  
1292  
1293  
1294  
1295  
1296  
1297  
1298  
1299  
1300  
1301  
1302  
1303  
1304  
1305  
1306  
1307  
1308  
1309  
1310  
1311  
1312  
1313  
1314  
1315  
1316  
1317  
1318  
1319  
1320  
1321  
1322  
1323  
1324  
1325  
1326  
1327  
1328  
1329  
1330  
1331  
1332  
1333  
1334  
1335  
1336  
1337  
1338  
1339  
1340  
1341  
1342  
1343  
1344  
1345  
1346  
1347  
1348  
1349  
1350  
1351  
1352  
1353  
1354  
1355  
1356  
1357  
1358  
1359  
1360  
1361  
1362  
1363  
1364  
1365  
1366  
1367  
1368  
1369  
1370  
1371  
1372  
1373  
1374  
1375  
1376  
1377  
1378  
1379  
1380  
1381  
1382  
1383  
1384  
1385  
1386  
1387  
1388  
1389  
1390  
1391  
1392  
1393  
1394  
1395  
1396  
1397  
1398  
1399  
1400  
1401  
1402  
1403  
1404  
1405  
1406  
1407  
1408  
1409  
1410  
1411  
1412  
1413  
1414  
1415  
1416  
1417  
1418  
1419  
1420  
1421  
1422  
1423  
1424  
1425  
1426  
1427  
1428  
1429  
1430  
1431  
1432  
1433  
1434  
1435  
1436  
1437  
1438  
1439  
1440  
1441  
1442  
1443  
1444  
1445  
1446  
1447  
1448  
1449  
1450  
1451  
1452  
1453  
1454  
1455  
1456  
1457  
1458  
1459  
1460  
1461  
1462  
1463  
1464  
1465  
1466  
1467  
1468  
1469  
1470  
1471  
1472  
1473  
1474  
1475  
1476  
1477  
1478  
1479  
1480  
1481  
1482  
1483  
1484  
1485  
1486  
1487  
1488  
1489  
1490  
1491  
1492  
1493  
1494  
1495  
1496  
1497  
1498  
1499  
1500  
1501  
1502  
1503  
1504  
1505  
1506  
1507  
1508  
1509  
1510  
1511  
1512  
1513  
1514  
1515  
1516  
1517  
1518  
1519  
1520  
1521  
1522  
1523  
1524  
1525  
1526  
1527  
1528  
1529  
1530  
1531  
1532  
1533  
1534  
1535  
1536  
1537  
1538  
1539  
1540  
1541  
1542  
1543  
1544  
1545  
1546  
1547  
1548  
1549  
1550  
1551  
1552  
1553  
1554  
1555  
1556  
1557  
1558  
1559  
1560  
1561  
1562  
1563  
1564  
1565  
1566  
1567  
1568  
1569  
1570  
1571  
1572  
1573  
1574  
1575  
1576  
1577  
1578  
1579  
1580  
1581  
1582  
1583  
1584  
1585  
1586  
1587  
1588  
1589  
1590  
1591  
1592  
1593  
1594  
1595  
1596  
1597  
1598  
1599  
1600  
1601  
1602  
1603  
1604  
1605  
1606  
1607  
1608  
1609  
1610  
1611  
1612  
1613  
1614  
1615  
1616  
1617  
1618  
1619  
1620  
1621  
1622  
1623  
1624  
1625  
1626  
1627  
1628  
1629  
1630  
1631  
1632  
1633  
1634  
1635  
1636  
1637  
1638  
1639  
1640  
1641  
1642  
1643  
1644  
1645  
1646  
1647  
1648  
1649  
1650  
1651  
1652  
1653  
1654  
1655  
1656  
1657  
1658  
1659  
1660  
1661  
1662  
1663  
1664  
1665  
1666  
1667  
1668  
1669  
1670  
1671  
1672  
1673  
1674  
1675  
1676  
1677  
1678  
1679  
1680  
1681  
1682  
1683  
1684  
1685  
1686  
1687  
1688  
1689  
1690  
1691  
1692  
1693  
1694  
1695  
1696  
1697  
1698  
1699  
1700  
1701  
1702  
1703  
1704  
1705  
1706  
1707  
1708  
1709  
1710  
1711  
1712  
1713  
1714  
1715  
1716  
1717  
1718  
1719  
1720  
1721  
1722  
1723  
1724  
1725  
1726  
1727  
1728  
1729  
1730  
1731  
1732  
1733  
1734  
1735  
1736  
1737  
1738  
1739  
1740  
1741  
1742  
1743  
1744  
1745  
1746  
1747  
1748  
1749  
1750  
1751  
1752  
1753  
1754  
1755  
1756  
1757  
1758  
1759  
1760  
1761  
1762  
1763  
1764  
1765  
1766  
1767  
1768  
1769  
1770  
1771  
1772  
1773  
1774  
1775  
1776  
1777  
1778  
1779  
1780  
1781  
1782  
1783  
1784  
1785  
1786  
1787  
1788  
1789  
1790  
1791  
1792  
1793  
1794  
1795  
1796  
1797  
1798  
1799  
1800  
1801  
1802  
1803  
1804  
1805  
1806  
1807  
1808  
1809  
1810  
1811  
1812  
1813  
1814  
1815  
1816  
1817  
1818  
1819  
1820  
1821  
1822  
1823  
1824  
1825  
1826  
1827  
1828  
1829  
1830  
1831  
1832  
1833  
1834  
1835  
1836  
1837  
1838  
1839  
1840  
1841  
1842  
1843  
1844  
1845  
1846  
1847  
1848  
1849  
1850  
1851  
1852  
1853  
1854  
1855  
1856  
1857  
1858  
1859  
1860  
1861  
1862  
1863  
1864  
1865  
1866  
1867  
1868  
1869  
1870  
1871  
1872  
1873  
1874  
1875  
1876  
1877  
1878  
1879  
1880  
1881  
1882  
1883  
1884  
1885  
1886  
1887  
1888  
1889  
1890  
1891  
1892  
1893  
1894  
1895  
1896  
1897  
1898  
1899  
1900  
1901  
1902  
1903  
1904  
1905  
1906  
1907  
1908  
1909  
1910  
1911  
1912  
1913  
1914  
1915  
1916  
1917  
1918  
1919  
1920  
1921  
1922  
1923  
1924  
1925  
1926  
1927  
1928  
1929  
1930  
1931  
1932  
1933  
1934  
1935  
1936  
1937  
1938  
1939  
1940  
1941  
1942  
1943  
1944  
1945  
1946  
1947  
1948  
1949  
1950  
1951  
1952  
1953  
1954  
1955  
1956  
1957  
1958  
1959  
1960  
1961  
1962  
1963  
1964  
1965  
1966  
1967  
1968  
1969  
1970  
1971  
1972  
1973  
1974  
1975  
1976  
1977  
1978  
1979  
1980  
1981  
1982  
1983  
1984  
1985  
1986  
1987  
1988  
1989  
1990  
1991  
1992  
1993  
1994  
1995  
1996  
1997  
1998  
1999  
2000  
2001  
2002  
2003  
2004  
2005  
2006  
2007  
2008  
2009  
2010  
2011  
2012  
2013  
2014  
2015  
2016  
2017  
2018  
2019  
2020  
2021  
2022  
2023  
2024  
2025  
2026  
2027  
2028  
2029  
2030  
2031  
2032  
2033  
2034  
2035  
2036  
2037  
2038  
2039  
2040  
2041  
2042  
2043  
2044  
2045  
2046  
2047  
2048  
2049  
2050  
2051  
2052  
2053  
2054  
2055  
2056  
2057  
2058  
2059  
2060  
2061  
2062  
2063  
2064  
2065  
2066  
2067  
2068  
2069  
2070  
2071  
2072  
2073  
2074  
2075  
2076  
2077  
2078  
2079  
2080  
2081  
2082  
2083  
2084  
2085  
2086  
2087  
2088  
2089  
2090  
2091  
2092  
2093  
2094  
2095  
2096  
2097  
2098  
2099  
2100  
2101  
2102  
2103  
2104  
2105  
2106  
2107  
2108  
2109  
2110  
2111  
2112  
2113  
2114  
2115  
2116  
2117  
2118  
2119  
2120  
2121  
2122  
2123  
2124  
2125  
2126  
2127  
2128  
2129  
2130  
2131  
2132  
2133  
2134  
2135  
2136  
2137  
2138  
2139  
2140  
2141  
2142  
2143  
2144  
2145  
2146  
2147  
2148  
2149  
2150  
2151  
2152  
2153  
2154  
2155  
2156  
2157  
2158  
2159  
2160  
2161  
2162  
2163  
2164  
2165  
2166  
2167  
2168  
2169  
2170  
2171  
2172  
2173  
2174  
2175  
2176  
2177  
2178  
2179  
2180  
2181  
2182  
2183  
2184  
2185  
2186  
2187  
2188  
2189  
2190  
2191  
2192  
2193  
2194  
2195  
2196  
2197  
2198  
2199  
2200  
2201  
2202  
2203  
2204  
2205  
2206  
2207  
2208  
2209  
2210  
2211  
2212  
2213  
2214  
2215  
2216  
2217  
2218  
2219  
2220  
2221  
2222  
2223  
2224  
2225  
2226  
2227  
2228  
2229  
2230  
2231  
22

Table 1

Innermost resin layer			Laminated foam				0.29dX	
MFR :X (g/10 min)	Thickness :Y ( $\mu$ m)	Density of foam : d (g/L)	Thickness (mm)	Closed cell ratio (%)	Surface resistivity ( $\Omega$ )			
Examples	1	5	194	225	3.1	87	$1.5 \times 10^{12}$	326
	2	10	150	130	4.0	85	$6.6 \times 10^{10}$	377
	3	17	150	130	4.0	87	$5.8 \times 10^{11}$	641
	4	10	150	130	4.0	73	$3.2 \times 10^{12}$	377
	5	10	150	130	4.0	83	$4.3 \times 10^{12}$	377
	6	32	150	130	4.0	87	$6.2 \times 10^{12}$	1206
	7	5	150	130	4.0	82	$9.5 \times 10^{10}$	189
	8	10	150	130	4.0	85	$6.7 \times 10^{10}$	377
	9	17	150	130	4.0	87	$4.4 \times 10^{10}$	641
	10	10	150	130	4.0	84	$1.5 \times 10^{12}$	377
	11	12	117	143	4.0	86	$2.4 \times 10^{12}$	498
	12	12	154	143	5.0	82	$3.0 \times 10^{12}$	498
Comparative examples	1	5	194	130	5.0	55	$1.5 \times 10^{12}$	189
	2	2	150	130	4.0	42	$1.2 \times 10^{11}$	75
	3	5	194	111	4.0	50	$8.0 \times 10^{10}$	161

Table 2

	Innermost resin layer			Outermost resin layer			Basis weight of each layer of laminated foam (outermost resin layer/innermost resin layer/foam/innermost resin layer/outermost resin layer) (g/m <sup>2</sup> )
	Type	MFR (g/10 min)	Layer thickness ( $\mu$ m)	Type	Amount of antistatic agent added (wt.%)	MFR $\alpha/\beta$ (g/10 min)	Layer thickness ( $\mu$ m)
Examples	1 Resin I	5	194	Polymer A/Resin I	15	17/5	28
	2 Resin II*	10	150	Polymer A/Resin II	ditto	17/10	ditto
	3 Resin III	17	150	Polymer A/Resin III	ditto	17/17	28
	4 Resin II*	10	150	Polymer B/Resin II*	15	21/10	ditto
	5 Resin II*	10	150	Polymer C/Resin II	20	70/10	ditto
	6 Resin IV	32	150	Polymer C/Resin IV	ditto	70/32	ditto
	7 Resin I*	5	150	Polymer E/Resin I	ditto	100 or more/5	ditto
	8 Resin II*	10	150	Polymer E/Resin II	ditto	100 or more/10	ditto
	9 Resin III*	17	150	Polymer E/Resin III	ditto	100 or more/17	ditto
	10 Resin II	10	150	Polymer D/Resin V	20	20/2	ditto
	11 Resin VII/Resin VIII	12	117	Polymer E/Resin VII/Resin VIII	15	100 or more/12	27
	12 Resin VII/Resin VIII	12	154	Polymer E/Resin VII/Resin VIII	15	100 or more/12	27
Comparative Examples	1 Resin I	5	194	Polymer A/Resin I	15	17/5	28
	2 Resin V	2	150	Polymer E/Resin V	15	100 or more/2	28
	3 Resin I	5	194	Polymer E/Resin I	15	100 or more/5	28

\*Thermoplastic elastomer (ethylene - octane random copolymer, MFR = 10.6 g/10 min), trade name AFFINITY EG8200 made by DOW CHEMICAL JAPAN, LTD., of 2.5 wt% was further added